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# Addressing Endogeneity of Casino, Crime and Regional Economy: A Case of Las Vegas, Nevada

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# ADDRESSING ENDOGENEITY OF CASINO, CRIME AND REGIONAL ECONOMY: A CASE OF LAS VEGAS, NEVADA

by

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# ABSTRACT

Addressing Endogeneity of Casino, Crime and Regional Economy: A Case of Las Vegas, Nevada

by

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This paper presents an approach to investigate the statistical relationship among casino activities, crime rates and number of visitors in Las Vegas, NV. Numerous studies have attempted to answer the question whether casino gaming increases crime rates. Casino gaming is statistically correlated with more crimes when researchers use the reported crime rate, i.e., ratio of the number of crimes to local population. However, there is no statistical relationship between the two when researchers use the visitor adjusted crime rate (henceforth adjusted crime rate), i.e., ratio of the number of crimes to local population and visitors, in their analyses. Somewhat surprisingly, previous studies have failed to consider the endogeneity issue, i.e., coincidental impacts of casino activities and crimes. This paper addresses endogeneity among variables by estimating the impact of casino activities on crimes and also impact of crimes on casino activities. To deal with endogeneity, a system of three equations representing casino activities, the number of visitors, and visitor adjusted crime rates is estimated using three stage least squares.

Elasticity of the casino revenue with respect to the adjusted crime rate is estimated to be $-0.22\pm0.1$ and elasticity of the adjusted crime rate with respect to casino revenue to be $0.29\pm0.27$. In addition, using the regression of the personal income on the casino revenue in Las Vegas, the impact of the adjusted crime rate on the regional economy is estimated. Results show that one percent increase in crime leads to cumulative decreases in the personal income by \$105±\$44 per household per year.

Policy implications based on findings in this research are i) efforts to reduce crime can be effective tool to boost the regional economy (in Las Vegas), ii) cutting the link between casino gambling and crime is important; to cut the link, pay more attention on education or regulation to reduce pathological gamblers, usurious loans and the fraud related to casino gambling, and iii) improving the image of casino gambling that are related to crimes and thus attracting more visitors.

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Wei Bao

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CHAPTER 1

# INTRODUCTION

## 1.1. Introduction

As of 2011, there are almost 500 commercial casinos operating in 22 states in the U.S., with revenues of over $35.6 billion (Table 1) (American Gaming Association (AGA), 2012). These commercial casinos have created about 340,000 job opportunities and paid almost $12.9 billion in wages (AGA, 2012). According to Bazelon, Neels and Seth (2012), the commercial casino industry supported $125 billion in spending and nearly 820,000 jobs in the U.S. economy (in 2010) including direct, indirect and induced impacts.[1] As shown in Figure 1 and Table 1, the casino revenue indeed increased quickly during the past two decades except 2007~2009 due to financial crisis. Walker (2010) points out that there is a "new wave of commercial casino legalization". The casino revenue of Nevada and Las Vegas, Nevada has the similar patterns in Figure 1.

The achievements of the gambling industry in Las Vegas stimulate the desire of policymakers and politicians in other states and regions, especially the regions without much competitiveness, to legalize casino gambling.

[1] Economic impacts are based on consumer (visitors) expenditures (direct effect). These expenditures affect the local and regional economy through the inter-industry relationships among different sectors and industries of the local economy. Casino visitors' expenditures on, say, gas, food and lodging, cause business-to-business (upstream, or indirect effects) exchanges as retailers make purchases from wholesale suppliers. Downstream effects (i.e., induced effects) occur as those employed by retailers and wholesalers use their wages to buy homes, cars, food, entertainment, etc.

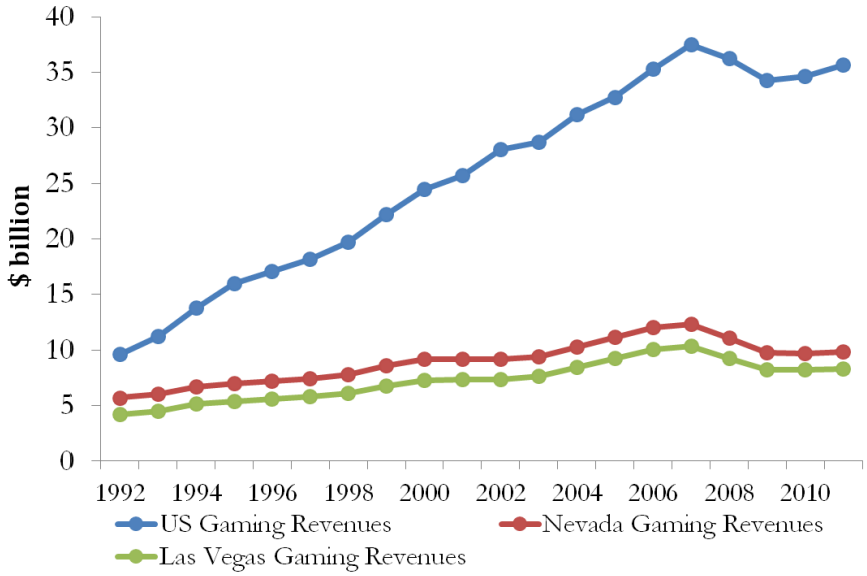


**Figure 1: Casino Revenues, 1992-2011**

Source: American Gaming Association (2001 and 2012); Nevada Gaming Commission and State Gaming Control Board (1992-2011)

Figure 2 shows that the growth rates of casino revenues for the U.S., Nevada, and Las Vegas, Nevada. For years, the growth rates of casino revenues are higher than that of the US GDP. The US casino revenue growth rates range from 5% to 20% before 2008. The average growth rate between 1993 and 2011 is 7.4%. As shown in Figure 2 the growth rates of casino revenue for the U.S. is higher than those of Nevada and Las Vegas. It is not only because there are more states that legalized commercial casinos over time, but also because more people consider the casino activities to be acceptable (See Figure 3).

**Table 1: Operating Casino Numbers and Gaming Revenue**

| State | Year Legalized | Operating Casino Numbers | | | Gaming Revenue ($ millions)[a] | | |
|---|---|---|---|---|---|---|---|
| | | 2001 | 2006 | 2011 | 2001 | 2006 | 2011 |
| Nevada | 1931 | 247 | 274 | 256 | 9,500 | 12,622 | 10,701 |
| New Jersey | 1976 | 12 | 11 | 11 | 4,300 | 5,219 | 3,318 |
| Iowa | 1989 | 13 | 19 | 18 | 923 | 1,573 | 1,424 |
| South Dakota | 1989 | 40 | 36 | 35 | 59 | 90 | 101 |
| Colorado | 1990 | 43 | 46 | 40 | 632 | 782 | 750 |
| Illinois | 1990 | 9 | 9 | 10 | 1,800 | 1,924 | 1,477 |
| Mississippi | 1990 | 30 | 27 | 30 | 2,700 | 2,570 | 2,239 |
| Louisiana | 1991 | 16 | 19 | 18 | 535 | 2,942 | 2,374 |
| Rhode Island | 1992 | | 2 | 2 | | 407 | 513 |
| Indiana | 1993 | 10 | 11 | 13 | 1,800 | 2,577 | 2,721 |
| Missouri | 1993 | 11 | 11 | 12 | | 1,592 | 1,805 |
| Delaware | 1994 | | 3 | 3 | 1,000 | 652 | 552 |
| West Virginia | 1994 | | 4 | 5 | | 976 | 959 |
| Michigan | 1996 | 3 | 3 | 3 | | 1,303 | 1,424 |
| New Mexico | 1997 | | 5 | 5 | | 238 | 249 |
| New York | 2001 | | 8 | 9 | | 424 | 1,259 |
| Maine | 2004 | | 1 | 1 | | 38 | 59 |
| Oklahoma | 2004 | | 3 | 2 | | 74 | 32,106 |
| Pennsylvania | 2004 | | 2 | 10 | | 10 | 3,024 |
| Florida | 2006 | | 2 | 5 | | | 382 |
| Kansas | 2007 | | | 2 | | | 48 |
| Maryland | 2008 | | | 2 | | | 156 |
| Total | | 434 | 496 | 492 | 24,348 | 36,043 | 35,641 |

[a] Current dollar

Source: American Gaming Association 2002, 2007, and 2012

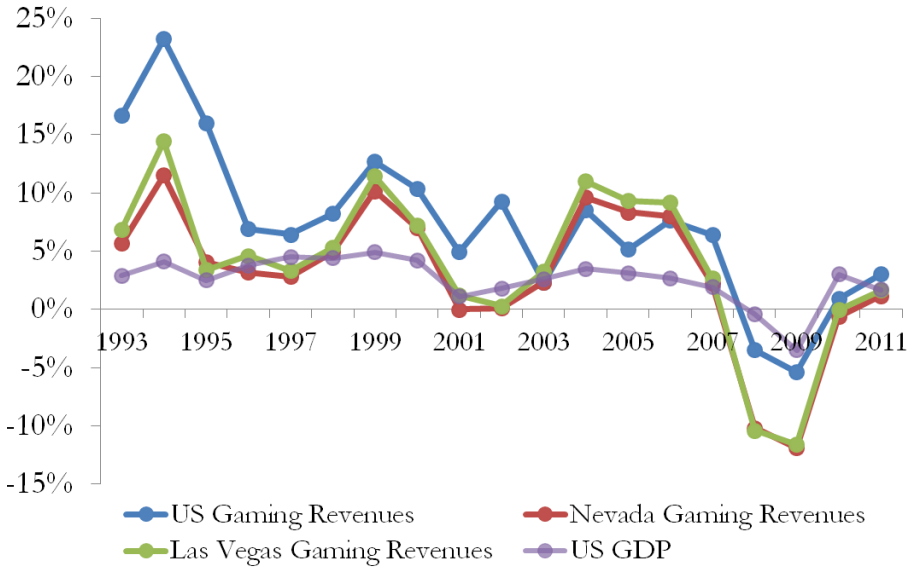


**Figure 2: The Growth Rates of Casino Revenues and US GDP, 1993-2011**
Source: American Gaming Association (2001 and 2012); Nevada Gaming Commission and State Gaming Control Board (1992-2011), and Bureau of Economic Analysis

There are more than 59.7 million people (about 25% of the US adult population) who gambled in casinos during 2011 (AGA, 2012). Higher demand for the legal casino services from the consumers, and the massive revenue gained from casinos and casino-related service industries have made local governments eager to legalize the casino industry.

Though the casino industry has become more prosperous, local community leaders and residents take this issue more prudently. In August 2012, the Governor of Illinois, Pat Quinn, vetoed an expansion plan of Chicago casinos that would have added five new casinos to the state (Chicago Tribune, 2012). In his veto message, Quinn said "the state must not allow ethical shortcomings that allow loopholes for mobsters." (Chicago Tribune, 2012) The action of Governor Quinn represents that there are issues and concerns arising when a local government contemplates to introduce or expand commercial casinos in a region.

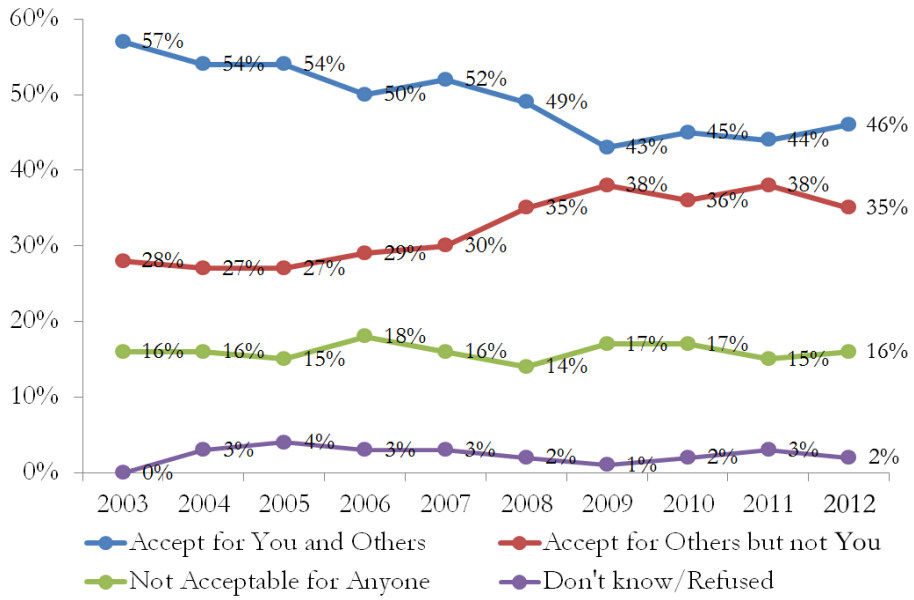


**Figure 3: U.S. Casino Gaming Acceptability, 2003-2012**
Source: Modified from American Gaming Association (2012, p.35)

Figure 3 shows that, in 2012, 46% of survey respondents take casino gambling as acceptable for anyone including themselves, and 35% take that as acceptable for anyone but not for themselves. In total, roughly 80% of survey respondents answered that casino gambling is acceptable.

However, 16% of respondents do not accept casino gaming (Figure 3). We observe in Figure 3 that the public are somewhat contradictory. We may interpret the survey results this way; more than 50% (Accept for Others not You 35% + Not Acceptable for Anyone 16%) of respondents do not like casino gambling for themselves. Plausible explanation is that people want to enjoy casino gambling, casino-related services and entertainments, but also are concerned negative effects that casino gambling may bring to the local community.

According to AGA (2012), potential negative impacts that casinos may bring to the communities are crime, prostitution and negative image of communities, "…hurt the image of communities where they are located" (AGA 2012, p. 27)[2]. In addition, there exist issues and concerns regarding casino business on the local economy which are tax revenues, employment and other non-gambling industries. Among them, the linkage between casino activities and crimes has attracted researchers' and policy makers' attention for decades.

### 1.2. Research Objectives

#### 1.2.1. Endogeneity between Casino Gambling and Crime

As mentioned above, an important concern regarding casino gambling is the connection between casino gambling and crime in the local community. It leads us to a natural question, whether the introduction or the expansion of casino gambling increases the crime incidences in the region. Thus, the first research question of the study is to investigate the relationship between casino gambling and crime.

Many studies (summarized in Table 2 in Chapter 2) have attempted to answer this question. Some early studies (studies published during 1985~2000) suggest that casino gambling causes a higher crime rate, for example, Friedman, Hakim and Weinblatt (1989), Hakim and Buck (1989), and Giacopassi and Stitt (1993). This is consistent with our intuition. If there is an increase in population and visitors in an area stimulated by the casino activities, there is likely to be more crime incidents. However, some of the other early studies

[2] Almost nine out of 10 community leaders, e.g., senators, mayors, city and county council members, fire or police chiefs, district attorneys and so on, disagree, saying this is not the case (AGA 2012, p. 27)

cannot find a clear linkage between casino gambling and crimes, e.g., Albanese (1985), Curran and Scarpitti (1991), Chang (1996), and Stokowski (1996).

Recent studies (studies published during 2001~2010) have relied on more complete data, larger markets, and advanced econometric analysis, however, the findings are mixed. Gazel, Rickmand and Thompson (2001), Evans and Topoleski (2002), and Grinols and Mustard (2006) claim that casinos increase crime rate. However, Wilson (2001), Barthe and Stitt (2007, 2009a, 2009b), Clark and Walker (2009), and Reece (2010) do not find the clear linkage between casinos and crimes.

Somewhat surprisingly, all of the studies listed in Table 2 ignore the endogeneity issue. Endogeneity, simultaneous determination, occurs between casino activities and crimes because there is a bi-directional causality between them as discussed in the following sections. Endogeneity of casinos and crime may lead us the inconclusive results due to the simultaneous bias. Endogeneity between casino activities and crime is investigated in order to address our first research goal.

### 1.2.2. Casino Gambling, Crime and Regional Economy

The connection between casino gambling and crime leads us to a related question, i.e., whether more crime incidents or a higher crime rate has negative impacts on casino gambling and, in turn, the regional economy. Generally, a region that adopted casinos has experienced increases in household income and employment (Garrett, 2004). However it seems likely that, a higher crime has a negative impact on the regional economy due to the fact that visitors would avoid regions where the crime rate is high. It can be critical in the region of which economy depends on the casino industry such as Las Vegas, Nevada. In this

study, the relationship between casino gambling and the regional economy is also investigated.

### 1.3. Organization of the Research

To achieve these research objectives, this study will build a simultaneous-equations system to estimate the effect of casinos on crime and vice versa, and measure the impact of casino and crime on the regional economy. This study is structured as follows. Chapter 2 explores the previous literature about casino gambling, crime and the regional economy, and discusses why we should consider endogeneity among variables. Chapter 3 outlines the structural model and methodology used in the study. Chapter 4 explains the data we use, some key variables in the model, and discusses the estimation results. Chapter 5 concludes the study, with a focus on policy implications.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1. Relationship between Casino Gambling and Crime

People are concerned that casino gambling may bring more crimes to the local community. Unfortunately studies that have investigated the relationship between casino gambling and crime have not provided a definite answer to the question of whether casino gambling increases crime.

Grinols and Mustard (2006) list five reasons that casino gambling may increase crimes:

i) Casino activities may lead to illegal casino-related activities, for example, prostitution, drug usage,

ii) Casino activities may increase crimes by increasing the potential payoffs of crime because visitors are considered to have more cash and be more vulnerable than locals,

iii) Casino activities may increase crime through pathological gamblers, bankruptcy, usurious loans, and fraud,

iv) Casino activities may increase crimes because it attracts more visitors and visitor criminals, and

v) Other industries related to casinos and its activities such as hotels and restaurants have a large demand for low skilled labors. This demand may change the composition of local residents and increase crimes[3].

Grinols and Mustard (2006) also mention that casino activities may also decrease crimes in two ways:

i) Casino activities may reduce crimes directly through offering jobs and paying wages, and

ii) Casino activities decrease crimes indirectly through increased tax revenue that local governments may have to spend on law enforcement.

Albanese (1985) points out that "no legitimate evidence is presented, such as convictions of (organized) criminals involved in (Atlantic City) casinos, to support their views…" (that casinos are connected with organized crime) (p. 40). Walker (2010) also points out that "most casinos are now corporate owned and managed, and the old stereotype of casinos as mob money-laundering operations has faded…" (p. 488).

Research investigating the relationship between casino gambling and crime was sparse until New Jersey legalized the commercial casinos in 1978. Walker (2010) divides the research history into two periods; early studies period (1985 ~ 2000) and recent studies period (2001~ 2010). Some early studies (1985 ~ 2000) suggest that casinos cause higher crime rate, e.g., Friedman, Hakim and Weinblatt (1989) and Hakim and Buck (1989) (See

[3] Grinols and Mustard (2006) claim that an increase in demand for unskilled and lower-income employees may alter the composition of the labor force and residents toward those who are more apt to engage in criminal activity without the rigorous tests.

Table 2 for summary of early studies). This is consistent with our intuition, which suggests that if there is a large increase in the population and visitors in an area, there is likely to be an increase in the number of crime incidents. However, some of the other early studies (1985 ~ 2000) could not find the clear linkage between crime and casinos, e.g., Albanese (1985) and Chang (1996).

Albanese (1985) argues that there is no connection between casino gambling and crime. Albanese (1985) points out that "crime statistics can be extremely misleading when they failed to account for: i) changes in population risk, ii) changes in criminal opportunities, iii) changes in law enforcement and priorities and iv) changes in crime elsewhere in the state," (pp. 40-41). In addition Albanese (1985) concludes that the actual risk of being victimized decreases if the crime rate is adjusted to the visitors. The importance of adjusted crime rate was reiterated by Miller and Schwartz (1998) and Walker (2008 and 2010).

Friedman, Hakim and Weinblatt (1989) and Hakim and Buck (1989) use similar regression analyses with panel data from the year before and after the introduction of casinos of the localities near and including Atlantic City, New Jersey. They compare the effect of casinos in pre-casino years and post-casino years and find that the level of crimes appears higher in the post-casino years than the pre-casino years in Atlantic City. They also find that there is a spillover effect that the localities adjacent to Atlantic City have a higher level of crimes (Friedman, Hakim and Weinblatt, 1989), and both distance and police outlays were associated with less crime (Hakim and Buck, 1989).

**Table 2: Casino-Crime Studies, 1985-2010**

| Study | Name of Journal | State/region studied | Year analyzed | Year casino opens | Casinos increase crime rate? | Population adjusted for visitors |
|---|---|---|---|---|---|---|
| Albanese (1985) | *Federal Probation* | Atlantic City | 1978-82 | 1978 | No | Yes |
| Friedman et al. (1989) | *Journal of Regional Science* | Atlantic City | 1974-84 | 1978 | Yes | No |
| Hakim and Buck (1989) | *Journal of Criminal Justice* | Atlantic City | 1972-84 | 1978 | Yes | No |
| Curran and Scarpitti (1991) | *Deviant Behavior* | Atlantic City | 1985-89 | 1978 | No | Yes |
| Giacopassi and Stitt (1993) | *Journal of Criminal Justice* | Atlantic City | 1991-93 | 1992 | Yes | No |
| Chang(1996) | *Journal of Criminal Justice* | Biloxi, MS | 1986-94 | 1992 | No | Yes |
| Stokowski(1996) | *Journal of Travel Research* | Biloxi, MS | 1989-94 | 1991 | No | Yes |
| General Accounting Office(2000) | *US General Accounting Office* | Atlantic City | 1977-97 | 1978 | No | Yes |
| Gazel, Rickman and Thompson (2001) | *Managerial and Decision Economics* | Wisconsin | 1981-94 | (Tribal) | Yes | No |
| Wilson(2001) | *Crime & Delinquency* | Indiana | 1992-97 | 1995 | No | No |
| Evans and Topoleski (2002) | *NBER Working Paper* | National (tribal only) | 1985-1989 | (various) | Yes | No |
| Stitt, Nichols and Giacopassi (2003) | *Crime & Delinquency* | Various | 1980s-1990s | (various) | Mixed | Yes |
| Betsinger (2005) | *University of Maryland Thesis* | 144 counties in 33 states | 1977-2001 | (various) | Mixed | No |
| Grinols and Mustard (2006) | *Review of Economics and Statistics* | All US counties | 1977-1996 | (various) | Yes | No |
| Barthe and Stitt (2007, 2009a, 2009b) | *Journal of Gambling Studies* | Reno, NV | 2003 | 1937 | No | Yes |
| Clark and Walker (2009) | *International Gambling Studies* | Various | 1994–95, 1996 and 2001–02 | (various) | No | Yes |
| Reece(2010) | *Contemporary Economic Policy* | Indiana | 1994-2004 | 1995 | No | Yes |

Source: Modified from Table 19.2 and Table 19.3 in Walker (2010)

Giacopassi and Stitt (1993) focus on Biloxi, Mississippi. They divide crimes into different categories to find the effect of the introduction of casino on each category. Giacopassi and Stitt (1993) conclude that "there is no significant difference between the two periods for total violent crime." (p. 124) and "failed to achieve statistical significance."(p. 126).

Chang (1996) measures the impact of casinos on crime on the basis of data for 118 criminal offenses collected from Biloxi, Mississippi, too. Overall, there was no increase in the crime rates during the first two years of casino introduction. During the first full year of casinos, there was a substantial decrease in crime rates, but the crime rates returned to the pre-casino level in the second year.

There are flaws in these early studies. Early studies do not have enough data to analyze the relationship between casinos and crimes because most of casinos were opened in 1990s (Walker, 2008). More importantly, as Walker (2008) points out, visitors are not included in the calculation of the crime rate in some early studies. Walker (2008) claims that crime rate "must be adjusted to account for the crime committed by visitors and for the increase in the population at risk of being victimized by crime".

Stitt, Nichols and Giacopassi (2003) compare the crime rates in six new casino jurisdictions to six non-casino control communities. The experimental and control communities were matched on 15 socioeconomic variables (p. 253). The results from their analysis are mixed. The authors conclude that "crime does not inevitably increase with the introduction of a casino into a community".

Betsinger (2005) analyzes the crime effects from various types of Native American and commercial land-based casinos, racinos, riverboat casinos, and Native American bingo halls. This research offers another way to check the relationship between casino and crime, i.e., which type of casino is more suitable for local community than the others. Betsinger (2005) examines the impact of gambling revenues in general on county-level crime rates and the impact of separate types of gambling revenues on county-level crime. She concludes that "both parts of the analysis produced mixed findings," (p.74) i.e., some types of crimes increases and some others types decreases, and some types of gambling revenues increase some types of crime and also decrease some types of crime.

Grinols and Mustard (2006) examine county-level crime data in every US counties from 1977 through 1996. They conclude that "after five years, 8.6% of the observed property crime and 12.6% of the violent crime in casino counties are due to casinos" (p. 42), and "the social crime cost associated with casinos is $75 per adult in 1996" (p. 44). Grinols and Mustard (2006) also claim that "crime was created in casino counties, rather than simply being shifted from one area to another" (p. 44). They conclude that casinos increased all crimes except murder.

Clark and Walker (2009) find that "there are some positive links between gambling and criminal activity" (p. 132). They find that the more money a person had lost in a particular year, the more likely the person was to commit a crime.

Reece (2010) utilizes some control variables in his model which were missing in previous studies. First, he uses the number of hotel rooms as a measure of tourism in his model. Second, he uses turnstile count of patrons entering the casinos as a measure of casino

activities. Third, he also includes law enforcement in studying the effects of casinos on crime which is also claimed very important by Albanese (1985). Reece concludes that "very limited support for the proposition that new casinos increase local crime rates." (p.157)

**2.2. Relationship between Casino and Regional Economy**

The second issue is the relationship between casinos and regional economy. Casinos and casino-related service industry will attract a large amount of visitors to the region because it is an entertainment industry. As an entertainment industry, casino industry does not demand a large amount of natural resource or highly skilled labor. Eadington (1999), points out that "jurisdictions that legalized casinos were often resource poor, or under economic duress. One or both of these factors apply to Monaco (1863), Nevada (1931), Macao (in the early 20th century), the Caribbean (1960s), and Atlantic City (1976), and help explain why many of the newly authorized American jurisdictions were keen on having casinos." (p. 187).

The success of Las Vegas casino gambling has precipitated the wave of legalizing casino gambling. Tourism, especially the number of visitors, is a key indicator that reflects the level of economic development. The local community benefits directly from the tax levied on the casino revenues and other related services revenue including hotels and restaurants. In addition, casino and casino related industries offer job opportunities to (low skilled) labor force in the local community. Rephann et al. (1997) report that "casino gaming is a popular strategy for local economic development in the United States..." (Rephann et al., 1997).

There are also side effects of casino gambling on the local economy. Gazel (1998) argues that "… should also examine the negative side associated with casino gambling and not focus only on the positive side of job creation and increased tax revenues." (Gazel, 1998, p.83). Eadington (1998) argues that "… the bulk of gambling revenues are generated by local residents… then spending on gambling reflects a reallocation of spending within the local or regional economy," (Eadington, 1998, p. 63). Even so, generally, rural counties that have adopted casino experience have higher household income and employment level (Garrett, 2004).

As discussed in many previous studies, the number of visitors is an important indicator of the level of local economy and its development. It leads us the question how crimes and visitors interact. Our intuition tells that there exists negative relationship, i.e., more crimes will lead to less visitors. Also, it is possible that the more visitors might induce more crimes (visitor criminals), and thus higher crime rates in the region. One interesting thing is that, whether there are differences between casino tourism and non-casino tourism or not.

Ochrym (1990) concludes that (in Atlantic City area) tourism (visitor) is not significantly different from non-casino tourism, and that the increased crime in Atlantic City is due to casinos, not tourism. Grinols and Mustard (2011) concludes that "national park visitors have no crime inducing effects, and therefore, that different visitor types have different crime effects." We agree with this conclusion that casino visitors are different with national park visitors because the act of gambling always involves money, win and lose. For

some people, it is only an entertainment, but for someone else it is a chance they would like to risk their money as if to invest it.

CHAPTER 3

# METHODOLOGY: SIMUTANEOUS EQUATION SYSTEM

## 3.1. Endogeneity

Casino gambling may decrease crimes or increase crimes (Grinols and Mustard, 2006), and both casino gambling and crimes interact with visitors as discussed in Chapter 2. This might be the reason that the previous studies do not have consistent results, i.e., casino gambling causes the more crimes. As shown in Table 3, researchers have not considered the possibility of endogeneity (jointly determined) issue, that is, crimes could also affect casino activities. All previous studies consider crime rates (or number of crime incidences) as the dependent variable and casino activities as the independent variable.

It is also noteworthy that most of previous studies use the dummy variable to indicate opening casinos in the region. There would be two reasons. First, most of studies attempt to compare the changes in crime before and after the introduction of casino. Second, there is no adequate measure to represent casino activities. Reece (2010) uses the number of hotel room and casino volumes for the casino activities.

We assume that more casinos activities would increase the crime rate, then with a higher crime rate, we expect that the number of visitors would decrease (perhaps population, too) because the visitors (and locals) try to avoid crimes. And, in turn, decreases in visitors would have a negative effect on casinos revenue. A lowered casinos revenue and casino activities reduces the crime because the region would have less visitors and visitor criminals. Less crime would increase the number of visitors and, in turn, casino's revenue.

**Table 3: Methodologies and Key Variables used in Previous Studies**

| Study | Region studied | Methodology | Dependent Variables | Key Independent Variables |
|---|---|---|---|---|
| Albanese (1985) | Atlantic City | Comparison | Number of crime incidents before and after the introduction of casinos | |
| Friedman et al. (1989) | Atlantic City | Regression | Crime rate | Casino dummy<br>Population size and density<br>Unemployment rate |
| Hakim and Buck (1989) | Atlantic City | Regression | Crime rate | Casino dummy<br>Unemployment rate<br>Property value<br>Number of police |
| Curran and Scarpitti (1991) | Atlantic City | Comparison | Crime rate before and after the introduction of casinos | |
| Giacopassi and Stitt (1993) | Atlantic City | Comparison | Number of crime incidents before and after the introduction of casinos | |
| Chang(1996) | Biloxi, MS | Regression | Number of crimes | Casino dummy |
| Stokowski(1996) | Biloxi, MS | Comparison | Crime rate before and after the introduction of casinos | |
| Gazel et al. (2001) | Wisconsin | Regression | Crime rate | Casino dummy<br>County fixed effect<br>Time fixed effect |
| Wilson(2001) | Indiana | Comparison | Crime incidents before and after the introduction of casinos | |
| Evans and Topoleski (2002) | National (tribal only) | Regression | Outcome of tribes (population, employment, unemployment rate, ratio of employment to adults, working but poor) | Casino dummy,<br>County demographics |
| Stitt et al. (2003) | Various | Comparison | Crime rate and population at risk before and after the introduction of casino | |
| Betsinger (2005) | 144 counties in 33 states | Regression | Crime rate | Casino opening variable<br>Casino type variable<br>Numbers of slots, table games, etc. |
| Grinols and Mustard (2006) | All US counties | Regression | Crime rate | Casino dummy<br>National crime rate trends<br>Population density, demographics (22 variables) |
| Barthe and Stitt (2007, 2009a, 2009b) | Reno, NV | Comparison | Compare the crime rate (2007), calls to police (2009a) and timing of calls for police (2009b) in casino and non-casino areas | |
| Clark and Walker (2009) | Various | Regression | Probability of committing serious crime | Gambling variables(individuals' current gambling practices)<br>Population demographics(income, unemployment rate, poverty rate) |
| Reece(2010) | Indiana | Regression | Crime rate | Hotel rooms<br>Turnstile count,<br>County fixed effects<br>Time fixed Effects |

In short, there is a loop of causality. Figure 4 illustrates the loop of the cause-and-effect relationship among crimes, visitors and casino activity. Greek letters in Figure 4 are coefficients in the structural model introduced later in this section. The symbol + indicates the positive effect and – indicates the negative impact. In other words, casinos, crime, and visitors should be considered simultaneously in a system of equations. The next section introduces the structural model.

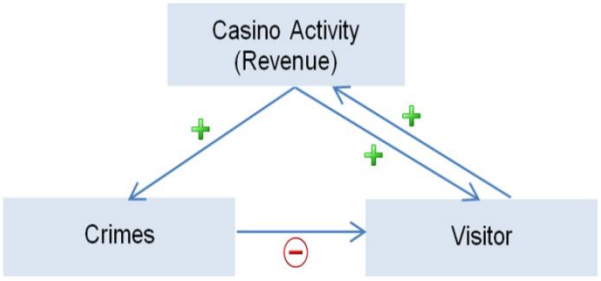


**Figure 4: A Causality Loop**

Note: The symbol + indicates a positive effect, and the symbol – indicates a negative effect between variables. The arrow shows the causal flow.

### 3.2. Simultaneous Model

To deal with endogeneity among variables, the system of equations describing casino activities, visitor and crime (or crime rate) is constructed. The casino revenue, which is the proxy of casino activities[4] in this research, is the function of the number of visitors that represents the casino gambling demand. Macro or regional economic condition may also

[4] The casino revenue may not be the appropriate proxy variable to represent casino activities in Las Vegas region. Casino activities include casino gambling and related businesses such as restaurants, leisure, convention, tour and travel, and other entertainments. Recent trend shows that the revenue from casino gambling is roughly 50% of the total regional tax revenue (personal communication with Professor Nichols, Department of Economics, University of Nevada, Reno)

affect the casino revenue. The Dow Jones Index is used as a composite proxy for these conditions. The Dow Jones Index describes the late-2000s financial crisis (credit crunch) well. The casino revenue equation is given by:

$$(1) \qquad \ln rvn_t = \alpha_0 + \alpha_1 \ln vstr_t + \alpha_2 \ln dow_t + \alpha_3 T + \sum_{i=1}^{i=11} \alpha_i month_i + \varepsilon_{1t},$$

where $t$ is the subscript for time (month), $rvn$ is the casino revenue, $vstr$ is the number of visitors, $dow$ is the Dow Jones Index, $T$ is a trend variable. The trend variable captures the effects that hard to observe but affect the casino revenue and is correlated with time. Lastly, the variable $month$ is monthly dummy which captures seasonality in the casino revenue data as described in data section. The number of visitors is expected to have a positive impact on the casino revenue. The sign of $dow$ is also expected to be positive. The casino revenue equation has one endogenous variable ($vstr$) and thirteen exogenous variables ($dow$, $T$, $month_i$).

A visitor equation is a function of the casino revenue as the proxy of casinos activities, the crime rate, and the proxy for general economic condition. The visitor equation is:

$$(2) \qquad \ln vstr_t = \beta_0 + \beta_1 \ln rvn_t + \beta_2 \ln crm_t + \beta_3 \ln dow_t + \beta_4 T + \sum_{i=1}^{i=11} \beta_i month_i + \varepsilon_{2t},$$

where $crm$ is the crime rate. The expected sign of the casino revenue is positive (more casino activities attract more visitors), and the expected sign of crime is negative (visitors tend to avoid high crime area). The expected sign of $dow$ is expected to be positive. The visitor equation contains two endogenous variables ($rvn$, $crm$) and thirteen exogenous variables ($dow$, $T$, $month_i$).

A crime equation includes the casino revenue, and the Dow Jones Index. We drop the number of visitor from the crime equation because the crime rate includes the visitor information in it. The crime equation includes the crime clearance rate that measures the deterrence or effectiveness of law enforcement[5]. The crime equation is given by:

$$(3) \qquad \ln crm_t = \delta_0 + \delta_1 \ln rvn_t + \delta_2 \ln clear_t + \delta_3 \ln dow_t + \delta_4 T + \sum_{i=1}^{i=11} \delta_i month_i + \varepsilon_{3t},$$

where $clear$ is the crime clearance rate. The crime equation contains one endogenous variable ($rvn$), and fourteen exogenous variables ($clear$, $dow$, $T$, $month_i$).

### 3.3. Income Equation

In addition, the regional income equation is considered to portray the connection between the regional income, measured by the per capita income, and the casino revenue in the region[6]. The direct lag model is the straightforward way of computing an effect and duration interval[7] of the casino revenue on the regional income. Assume that the regional income at time t is a linear function of the present and past casino revenue only; the income equation is given by:

$$(4) \qquad \ln inc_t = \phi_0 + \sum_{i=0}^{n} \phi_i \ln rvn_{t-i} + \phi_T T + \sum_{j=1}^{3} \phi_j quarter_j + \varepsilon_{4t},$$

where $inc$ is per capita income in the region, and $rvn_{t-i}$ is the casino revenue in time $t - i$.

---

[5] According to Becker (1968), criminals are rational and will react to incentives, that is, the expected punishment for commuting crimes. Levitt (1996 and 1997) shows that deterrence has negative impact on crime.

[6] Note that the income equation is not included in the system of equations because of the data interval. The per capita income data is available on quarterly basis not monthly basis.

[7] The regional income would respond to the casino revenue (in Las Vegas) spontaneously while there would be a time lagged effect because i) it takes time for businesses and local residents to adjust to changes in the casino revenue, and ii) changing taxes and local government spending due to changes in the casino revenue has a significant lag time to take an effect.

Since the number of regressors could be infinite, estimation of equation (4) is not feasible. Even if the lag were arbitrarily truncated, it might still be difficult to obtain precise estimates because the casino revenue is likely to be highly autocorrelated (actually it is), implying potentially severe multicollinearity (Clarke, 1976). The most popular model is the Koyck (1954) distributed lag model. It is usually derived from the direct lag equation (4) in which n is assumed to be infinite and the decay is exponentially declining, i.e., there is a real number $\lambda$ such that $0 \le \lambda \le 1$ and $\phi_i = \lambda \phi_{i-1}$ for $i = 1, 2, \ldots$ Then equation (4) reduces to

$$\ln inc_t = \phi_0(1-\lambda) + \phi_r \ln rvn_t + \lambda \ln inc_{t-1} + \phi_T T + \sum_{j=1}^{3} \phi_j quarter_j + v_t, \tag{5}$$

where $v_t = \varepsilon_{4t} - \lambda \varepsilon_{t-1}$. The transformation of equation (4) into equation (5) is called the Koyck transformation. This transformation reduces the number of parameters to estimate and the multicolliniearity problem (Griffths, Hill, and Judge, 1993, p. 690).

It is noteworthy that equation (5) gives important implication such that estimates of the instantaneous effect of the casino revenue, the parameter $\phi_r$ (Leach and Reekie, 1996), and immediate carryover effect of the casino revenue, the parameter $\lambda$, obtained directly. Therefore $1 - \lambda$ represents the rate of the casino revenue decay (Berndt, 1991). The cumulative effect of the casino revenue on the regional income after $m$ periods, i.e., the instantaneous plus the carryover effect, equals $\phi_r(1 + \lambda + \lambda^2 + \cdots + \lambda^{m-1}) = \phi_r(1-\lambda^m)/(1-\lambda)$. As m approaches infinity, the total cumulative impact of the casino revenue on the regional income converges to

$$\text{CumulativeEffect} = \frac{\phi_r}{(1-\lambda)}. \tag{6}$$

### 3.4. Estimation and Elasticities

There are several methods for estimating simultaneous equations. The two-stage least-squares (2SLS) is efficient and consistent but it ignores information concerning the endogenous variables which appear in the system but not in individual equations (Judge et al. 1988). A seemingly unrelated regression (SUR) accounts for the correlation in the error terms across equations but does not consider the endogenous problem in each question. Three-stage least squares (3SLS) is considered a combination of 2SLS and SUR. It accounts for the contemporaneous correlation in the error terms across equations and the correlation of the right hand side variables with the error term. Furthermore, it is asymptotically more efficient than 2SLS (Judge et al. 1988). Thus, we adopt 3SLS to estimate the system of equations.

Elasticities are then calculated using the chain-rule from the system of equations such that:

The elasticities with respect to *crm*:

$$\frac{\partial \ln rvn}{\partial \ln crm} = \frac{\partial \ln rvn}{\partial \ln vstr} \cdot \frac{\partial \ln vstr}{\partial \ln crm} = \alpha_1 \beta_2 \quad , \quad \frac{\partial \ln vstr}{\partial \ln crm} = \beta_2$$

The elasticities with respect to *rvn*:

$$\frac{\partial \ln vstr}{\partial \ln rvn} = \beta_1 \quad , \quad \frac{\partial \ln crm}{\partial \ln rvn} = \delta_1$$

The elasticities with respect to *vstr*:

$$\frac{\partial \ln rvn}{\partial \ln vstr} = \alpha_1 \quad , \quad \frac{\partial \ln crm}{\partial \ln vstr} = \frac{\partial \ln crm}{\partial \ln rvn} \cdot \frac{\partial \ln rvn}{\partial \ln vstr} = \alpha_1 \delta_1$$

In this manner we can derive elasticities of endogenous variables with respect to endogeneous variables in the system.

The disturbance in the income equation in equation (5) follows a first order moving average process, i.e., $v_t = \varepsilon_{4t} - \lambda\varepsilon_{t-1}$ , and is correlated with the $inc_{t-1}$ regressor, and therefore the least square estimation is biased and inconsistent. To obtain the consistent results, the autocorrelation should be fixed.

CHAPTER 4

# STUDY REGION AND DATA

Las Vegas, Nevada is selected as the study region to build the simultaneous equation system in equations (1), (2), and (3). Las Vegas is selected because Las Vegas has the longest history of casino industry (legalized in 1931) as well as the casino business has been one of the most important industries in the region.

Somewhat interestingly, there is no study investigating the relationship between casino and crime in Las Vegas (See Table 2). In the previous studies, researchers have focused on how the introduction of casinos would affect the crime (or crime rate), i.e., changes in crime (or crime rate) before and after casino introduction. However, in Las Vegas, it is impossible to collect crime data before it was legalized in 1931 since no data was collected.

## 4.1. Data Collection and Key Variables

The data set for the empirical analysis is comprised of monthly data spanning from January 1996 to July 2011 (187 observations).

### 4.1.1. Crime Rate

The crime data are compiled from Uniform Crime Reporting (UCR) in Nevada Department of Public Safety[8]. Two types of crime rates, a reported crime rate and an adjusted crime rate, are calculated based on the population and population adjusted for the

[8] Available at http://nvrepository.state.nv.us/crimejustice.shtml; UCR data include homicide, forcible rape, robbery, assault, burglary, larceny-theft, motor vehicle theft, and arson.

visitors as suggested in Albanese (1985) and Walker (2008). Figure 5 shows the reported crime rates and the adjusted crime rates[9] in Las Vegas from January 1996-July 2011. The reported crime rate is decreasing over time but the adjusted crime rate is fairly constant (slightly decreasing)[10].

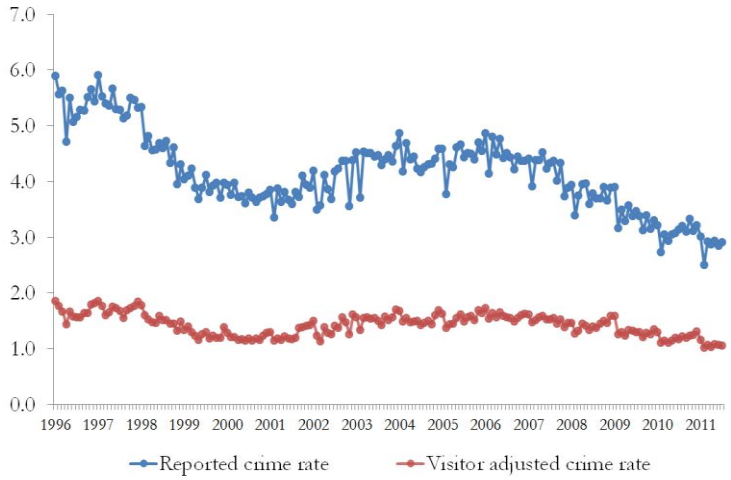


**Figure 5: Plots of Crime Rate (per 1000 persons)**
Source: Crime incidences are collected from the Uniform Crime Reporting (UCR) in Nevada Department of Public Safety. Crime rates are calculated by author.

### 4.1.2. Casino Revenue

Researchers have used different measures of casino activities, for example, Grinols and Mustard (2006) use the dummy variable, e.g., one indicates the casino opening, zero otherwise. Reece (2010) uses the number of hotel rooms and Betsinger (2005) uses the

[7] Reported crime rate = $(C_R + C_V)/P_R$, Adjusted crime rate = $(C_R + C_V)/(P_R + P_V)$, where $C_R$ = crimes committed by residents, $C_V$ = crime committed by visitors, $P_R$ = resident's population, $P_V$ = visitors' population. By construction the reported crime rate is always higher than adjusted crime rate.

[8] A possible explanation for this is because of the decrease of crime incidents and the growth rate of local population is higher than that of visitors.

number of slot machines as an index of casino activities. We use the win amount (money the casino takes) or casino revenue as the index of the casino activities. Casino revenue data are obtained from Nevada Gaming Commission and State Gaming Control Board[11] and deflated using GDP deflators (Figure 6). From Figure 6, we find that casino revenue has a strong seasonality and starts decreasing at the end of 2007 and it stays decreasing trend. It is likely that the decreases in casino revenue stem from the financial economic crisis in late 2000s. As shown in Figure 6, there exists a strong seasonality.

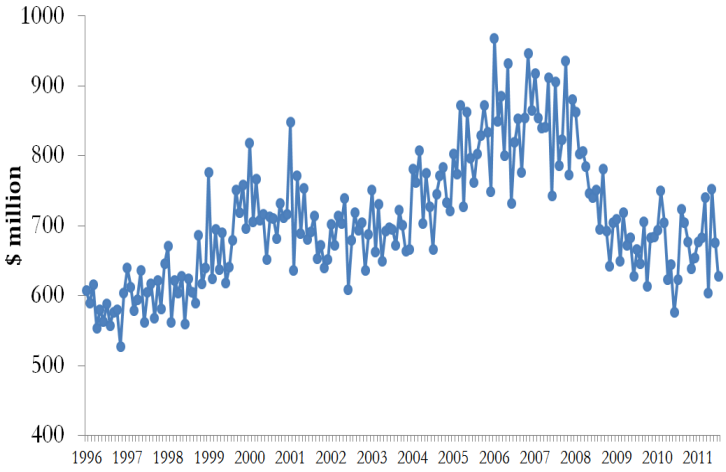


**Figure 6: Plots of Gaming Revenue, Deflated (million dollars)**
Source: Nevada Gaming Commission and State Gaming Control Board

### 4.1.3. Visitors

The visitor data are obtained from the statistical reports in Las Vegas Convention and Visitor Authority[12]. Figure 7 shows the number of visitors of Las Vegas from January 1996 - July 2011. As shown in Figure 7, there exists a strong seasonality.

[11] Available at http://gaming.nv.gov/
[12] Available at http://www.lvcva.com/

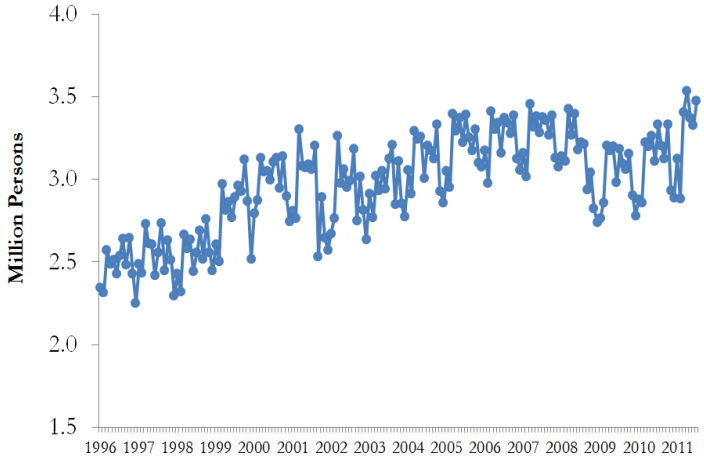


**Figure 7: Plots of Visitors (million persons)**
Source: Las Vegas Convention and Visitor Authority

### 4.1.4. Other Variables and Basic Statistics

We use the Dow Jones Index as an index of US economic condition to describe the 2008-2009 financial downturns. When Dow Jones Index is high, the US economy is likely to be performing well and thus it may stimulate visitors to visit Las Vegas area more frequently. Dow Jones Index is obtained from EconStats (www.econstats.com). Basic statistical elements are shown in Table 4.

**Table 4: Basic Statistics (January 1996 ~ July 2011)[a]**

| | Casino Revenue[b] | Reported Crime Rate | Adjusted Crime Rate | Visitors | Dow Jones Index |
|---|---|---|---|---|---|
| Unit | ($ million) | (per 1000 | (per 1000 persons) | (million persons) | |
| Average | 709.80 | 4.15 | 1.42 | 2.96 | 9897.90 |
| Std.Dev | 91.34 | 0.70 | 0.20 | 0.30 | 1897.00 |
| CV (%) | 12.87 | 16.90 | 13.73 | 10.15 | 19.17 |
| Min | 528.96 | 2.50 | 1.01 | 2.25 | 5117.12 |
| Median | 700.48 | 4.17 | 1.45 | 3.01 | 10273.60 |
| Max | 967.81 | 5.91 | 1.85 | 3.53 | 13924.20 |
| Count | 187.00 | 187 | 187 | 187 | 187 |

Note: [a] Monthly Data; [b] Deflated using GDP deflator

### 4.2. Results and Discussion

#### 4.2.1. Casino Revenue, Visitors, and Adjusted Crime Equations

Regression results of the system with the adjusted crime rate are presented in Table 5 and most of the coefficients have the expected signs[13]. Table 5 also contains the results for the single equation model using the least squares for the comparison. From Table 5 we observe followings.

Casino revenue equation (Equation 1):

The coefficient of visitors is positive and statistically significant, i.e., the more visitors, the more casino revenues, which is obvious. The coefficient of Dow is positive and statistically significant; it implies that the casino revenue is higher when the US economy is better. Trend variable is also statistically significant but has the negative sign. The single equation model results are similar but different magnitudes, for example, the economic situation (Dow variable) has much stronger impact on the casino revenue. Note that the serial correlation is detected in all three equations with the Breusch-Godfrey test[14]. It is fixed using Prais–Winsten process[15].

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[13] The system of equations with the **reported crime rate** are also estimated and presented in Appendix A to compare the differences between the adjusted crime rate and the reported crime rate and to test robustness of the estimation.

[14] The Breusch-Godfrey test is a Lagrange multiplier test of $H_0$: no autocorrelation versus $H_1$: errors = AR(p). The test is carried out by regressing the OLS residuals on regressors and referring $TR^2$ to the tabled critical value for the chi-squared distribution with p degrees of freedom (Greene, 2000, p.541).

[15] Prais-Winsten estimation is a procedure to take care of the serial correlation in a linear model. It is a modification of Cochrane-Orcutt estimation in the sense that it does not lose the first observation (Wooldridge, 2009, p. 422).

**Table 5: 3SLS Estimation Results with Adjusted Crime Rate**[a]

| Equation | Variable | 3SLS | OLS[b] |
|---|---|---|---|
| | | Coefficient | Coefficient |
| ln(Casino Revenue) | ln(Visitors) | 1.4295*** | 0.6831*** |
| | | (0.115) | (0.153) |
| | ln(Dow Jones Index) | 0.0911** | 0.2428*** |
| | | (0.040) | (0.057) |
| | Trend | –0.0011*** | -0.0005** |
| | | (0.000) | (0.000) |
| | Constant | 5.0309*** | 5.3640*** |
| | | (0.080) | (0.123) |
| | R squared | 0.7055 | 0.8687 |
| ln(Visitors) | ln(Casino Revenue) | 0.8243*** | 0.0504 |
| | | (0.083) | (0.031) |
| | ln(Adjusted Crime Rate) | -0.1560*** | -0.2291*** |
| | | (0.042) | (0.038) |
| | ln(Dow) | -0.1500*** | 0.0115 |
| | | (0.047) | (0.044) |
| | Trend | 0.0007*** | 0.0011*** |
| | | (0.000) | (0.000) |
| | Constant | –4.0659*** | 0.6272*** |
| | | (0.437) | (0.208) |
| | R squared | 0.7920 | 0.8355 |
| ln(Adjusted Crime Rate) | ln(Casino Revenue) | 0.2931** | 0.0859 |
| | | (0.139) | (0.061) |
| | ln(Clearance Rate) | –0.2895*** | –0.1581*** |
| | | (0.039) | (0.045) |
| | ln(Dow Jones Index) | -0.4099*** | -0.1881** |
| | | (0.065) | (0.085) |
| | Trend | -0.0005*** | -0.0009* |
| | | (0.000) | (0.001) |
| | Constant | 0.3846 | 0.8624* |
| | | (0.879) | (0.454) |
| | R squared | 0.6388 | 0.4346 |

Note: Numbers in parentheses are standard errors. Significance levels are 1% (***), 5% (**), and 10% (*).

[a] Monthly dummies are omitted to save space. Appendix A provides the complete estimation results

[b] Serial correlation is detected in all three equations using the Breusch–Godfrey test. The Prais–Winsten regression is used to fix the serial correlation.

Visitor equation (Equation 2):

We find that the coefficient of the casino revenue is positive and statistically significant, i.e., the more casino activities attract more visitors. The sign of the adjusted crime rate is, as expected, negative and statistically significant; the higher crime rate crowds out visitors from the region. The Dow has a negative sign and statistically significant, which is interesting; maybe it is because people tend to purchase other types of entertainments rather than the casino gambling when the economy is good. A bad economic situation may increase the number of visitors to the Las Vegas who want to take their chances on the casino gambling. The single equation results show the similar pattern but both the casino revenue and the Dow are not statistically significant which is not consistent with our intuition. The adjusted crime rate has much stronger impact on the number of visitors in the single equation model.

Adjusted crime equation (Equation 3):

The coefficient of the casino revenue is positive and statistically significant, which implies that the casino activities indeed increase the adjusted crime rate. Note that the coefficient of the casino revenue in the single equation model is not statistically significant and it is consistent with findings in other studies such as Walker (2008) (See Table 2 Summary of previous literature). As expected, the coefficients of the crime clearance rate have negative sign and statistically significant. It indicates that the effectiveness of the law enforcement has a negative effect on the adjusted crime rate. The Dow is negative and statistically significant, which is consistent with our intuition.

Elasticities

Elasticities of endogenous variables, i.e., casino revenue, visitors, and the adjusted crime rates, with respect to endogenous variables are derived using the chain rule as discussed in the previous section (Table 6). When the adjusted crime rate increases, it leads to the decrease in the number of visitors and the casino revenues. The casino revenue elasticity is estimated to be −0.22 and the 95% confidence band is given by −0.32 ~ −0.12. It implies that the casino revenue decreases by 0.12% ~ 0.32% when the adjusted crime rate increases by 1%. When the casino revenue increases by 1%, it leads to an increase in the adjusted crime rate by 0.29%. Note that the 95% confidence band of the adjusted crime rate elasticity is quite large, which is 0.02 ~ 0.57, but not zero.

**Table 6: Estimated Elasticities with 95% Confidence Bands**

| | Elasticities | | |
|---|---|---|---|
| Of / w.r.t | Revenue | Visitors | Adjusted Crime Rate |
| Adjusted Crime Rate | −0.2230<br>[-0.3230, -0.1230] | −0.1560<br>[-0.2390, -0.0730] | |
| Visitors | 1.4295<br>[1.2050, 1.6539] | | 0.4190<br>[0.0131, 0.8250] |
| Casino Revenue | | 0.8243<br>[0.6616, 0.9870] | 0.2931<br>[0.0200, 0.5663] |

Numbers in brackets are 95% confidence bands. Confidence bands are constructed based on the estimated variance-covariance of the estimated parameters in Table 5 (nlcom – nonlinear combination of estimators in STATA software).

Note: The numbers are elasticities. For example,-0.2230 means if the adjusted crime rate increase by 1%, the casino revenue will decrease by 0.2230%.

### 4.2.2. Income Equation

The economy of Las Vegas is largely dependent upon the performance of casino and casino-related industries. As a key index of the performance of an economy, we assume that there exists a close relationship between personal income and the casino revenue as shown in equation (5), the Koyck model.

The data of personal income are compiled from the BEA but the quarterly personal income data for Las Vegas region are unavailable. The quarterly data of per capita income of Las Vegas are generated from the annual data of Las Vegas and quarterly Nevada personal income data (See Appendix B for data interpolation). The basic statistics are reported in Table 7. Per capita income in Las Vegas region is $8,400 (2005 dollar) during spring 1996 – winter 2011. Average quarterly income in 2011 is $8,920 (2005 dollar).[16]

**Table 7: Basic Statistics (Spring 1996 ~ Winter 2011)[a]**

| | Per Capita Income[b] ($/person) | Casino Revenue[b] ($ million) |
|---|---|---|
| Average | 8,399.65 | 2122.46 |
| Std. Dev. | 531.20 | 248.15 |
| CV (%) | 6.32 | 11.69 |
| Min | 7,436.22 | 1697.48 |
| Median | 8,294.33 | 2083.08 |
| Max | 9,367.76 | 2703.00 |

[a] Quarterly data; number of observation = 64
[b] Deflated using GDP deflator (2005 = 100)

[16] For comparison, 2011 quarterly personal income for Nevada is $8,152 (2005 dollar) and 2011 quarterly personal income for the U.S. is $9,166 (2005 dollar).

The regression results of income equation are shown in Table 8. As expected, the income equation suffers from the serial correlation (Breusch-Godfrey LM test statistic = 14.87 and the null hypothesis is rejected) and fixed with the Prais-Wintern regression. As shown in Table 8, the short-run effect of the casino revenue is 0.11. It means that one percent increase in the casino revenue will result in an immediate increase in the personal income of 0.11%, which is small. The cumulative effect, by the way, is calculated using equation (6) which is given by 0.52 = 0.1071/(1 – 0.7930). It implies that a current increase in the casino revenue by 1% leads to a 0.52% increase in the personal income cumulatively.

**Table 8: Income Equation (Koyck Model)**[a]

| Equation | Variable | Coefficient | Std. Err |
|---|---|---|---|
| ln(Personal Income) | ln(Casino Revenue) | **0.1071***** | (0.035) |
| | ln(Personal Income **t-1**) | **0.7930***** | (0.063) |
| | ln(Dow Jones Index) | 0.0056 | (0.008) |
| | Trend | -0.0005*** | (0.008) |
| | Spring | -0.0305*** | (0.003) |
| | Summer | 0.0010 | (0.003) |
| | Fall | -0.0025 | (0.003) |
| | Constant | -0.4581 | (0.492) |
| | Rho | 0.5184 | |
| | R squared | 0.9995 | |
| | No. of Obs. | 63 | |

Note: Significant at 1% (***), 5% (**), and 10% (*) level; Serial correlation is detected in all three equations using the Breusch–Godfrey test. The Prais–Winsten regression is used to fix it. Durbin-Watson statistic (original) = 1.032; Durbin-Watson statistics (transformed) = 2.018

Using the elasticities in Table 6 and results in Table 8, we estimate the impact of the adjusted crime on the personal income in Las Vegas. The 1% increase in the adjusted crime rate leads to 0.22%±0.10% decreases in the casino revenue and thus, 0.02%±0.01% decreases in the personal income instantaneously.[17] It is equivalent to a loss of $7±$3 per person or $19$±8 per household[18] in 2011. Cumulatively, the 1% increase in the adjusted crime rate leads to 0.11%±0.05% decrease in the personal income.[19] It is equivalent to a loss of $39±$17 per person or $105±44 per household.

[17] Elasticity of the casino revenue with respect to crime is −0.22 (Table 6) and instantaneous elasticity of the personal income with respect to the casino revenue is 0.11 (Table 8). Thus 1% increase in the adjusted crime rate decreases the personal income by −0.02% = −0. 22% × 0.1071

[18] Assuming the household size is 2.72 persons (US Census Bureau quick facts)

[19] −0.11% = −0. 22% × 0.517

# CHAPTER 5
# CONCLUDING REMARKS AND POLICY IMPLICATIONS

Before concluding the study, one caveat should be addressed. The casino revenue may not be the appropriate proxy variable for the casino activities. Casino gambling, as a part of the entertainment industries in Las Vegas, only accounts for the part of local tax revenues. There are many other industries affiliated to casino industry such as hotels, restaurants, other tour and travel segments. There might be more appropriate proxy variables for casino activities, for example, hotel room occupancy.

A system of three equations representing the casino revenue, visitors and crime is estimated using 3SLS (Table 5). Results show that the adjusted crime has the negative impact on the casino revenue and the regional economy. One percent increase in the adjusted crime rate (in Las Vegas) would reduce the casino revenue by 0.22% ± 0.10% and in turn, cause 0.02% ± 0.01% instantaneous decrease in personal income (or equivalently $19 ± $8 loss per household) and 0.11%±0.05% decrease in the personal income (or equivalently $105±44 loss per household) cumulatively.

In considering the endogeneity, the effect of the casino activities on the adjusted crime rate is positive and statistically significant, which is a different finding from the previous studies. The elasticity of the crime with respect to the casino activities is estimated as 0.29± 0.27 in Las Vegas. One percent expansion of casino activities in Lag Vegas causes 19±17 more crime incidences per month.

Policy implications based on findings in this research are following:

- Efforts to reduce crime can be effective tool to boost the regional economy (in Las Vegas). For example, one percent higher crime clearance rate increases the casino revenue by 0.065% ± 0.024%[20].
- Cutting the link between casino gambling and crime is important: increases in casino activities attract the more visitors and boost the regional economy. However, the expansion of casino activities also increases the crime and thus the effect of expansion is alleviated. To cut the link, pay more attention on education or regulation to reduce pathological gamblers, usurious loans and the fraud related to casino gambling, and
- Cutting the link between visitors and crime is crucial: the number of visitors has the negative relationship with crime which implies visitors avoid high crime region. Thus, it is essential for policy makers to enhance the image of casino gambling and some sorts of advertising campaign to alleviate the link between visitors and crime, for example, emphasizing safe and comfortable casino gambling environment.

10 Using chain-rule, we have the elasticity of revenue with respect to clearance rate as follows:

$$\frac{\partial \ln rvn}{\partial \ln clear} = \frac{\partial \ln rvn}{\partial \ln vstr} \cdot \frac{\partial \ln vstr}{\partial \ln crm} \cdot \frac{\partial \ln crm}{\partial \ln clear} = \alpha_1 \beta_2 \delta_2$$

From Table 5, we have $a_1\beta_2\delta_2$= 0.0645, the confidence interval of which is [0.0404,0.0887]

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# APPENDIX

# APPENDIX A

**Table 9: 3SLS Regression Results with Adjusted Crime Rate**

| Equations | Variable | 3SLS | | OLS [a] | |
|---|---|---|---|---|---|
| | | Coefficient | Std. Err | Coefficient | Std. Err |
| ln(Casino Revenue) | ln(Visitors) | 1.4295*** | (0.115) | 0.6831*** | (0.153) |
| | ln(Dow Jones Index) | 0.0911** | (0.040) | 0.2428*** | (0.057) |
| | Trend | -0.0011*** | (0.000) | -0.0005** | (0.000) |
| | Constant | 5.0309*** | (0.080) | 5.3640*** | (0.123) |
| | Jan | 0.0114 | (0.025) | 0.0518** | (0.022) |
| | Feb | -0.0413* | (0.024) | -0.0182 | (0.024) |
| | Mar | -0.1655*** | (0.031) | -0.0450 | (0.035) |
| | Apr | -0.2037*** | (0.028) | -0.1114*** | (0.032) |
| | May | -0.1487*** | (0.028) | -0.0520 | (0.033) |
| | Jun | -0.1884*** | (0.026) | -0.1256*** | (0.029) |
| | Jul | -0.2017*** | (0.028) | -0.1058*** | (0.033) |
| | Aug | -0.1968*** | (0.029) | -0.0987*** | (0.034) |
| | Sep | -0.0891*** | (0.026) | -0.0378 | (0.028) |
| | Oct | -0.1604*** | (0.029) | -0.0587* | (0.032) |
| | Nov | -0.0863*** | (0.025) | -0.0490** | (0.022) |
| | R squared | 0.7055 | | 0.8687 | |
| ln(Visitors) | ln(Casino Revenue) | 0.8243*** | (0.083) | 0.0504 | (0.031) |
| | ln(Adjusted crime rate) | -0.1560*** | (0.042) | -0.2291*** | (0.038) |
| | ln(Dow Jones Index) | -0.1500*** | (0.047) | 0.0115 | (0.044) |
| | Trend | 0.0007*** | (0.000) | 0.0011*** | (0.000) |
| | Constant | -4.0659*** | (0.437) | 0.6272*** | (0.208) |
| | Jan | -0.0219 | (0.019) | 0.0461*** | (0.008) |
| | Feb | 0.0073 | (0.019) | -0.0008 | (0.011) |
| | Mar | 0.0873*** | (0.020) | 0.1269*** | (0.013) |
| | Apr | 0.1250*** | (0.018) | 0.0948*** | (0.013) |
| | May | 0.0835*** | (0.019) | 0.1072*** | (0.014) |
| | Jun | 0.1239*** | (0.018) | 0.0663*** | (0.014) |
| | Jul | 0.1255*** | (0.018) | 0.1042*** | (0.014) |
| | Aug | 0.1204*** | (0.019) | 0.1129*** | (0.013) |
| | Sep | 0.0477** | (0.018) | 0.0504*** | (0.012) |
| | Oct | 0.0946*** | (0.019) | 0.1134*** | (0.011) |
| | Nov | 0.0507*** | (0.018) | 0.0325*** | (0.008) |
| | R squared | 0.7920 | | 0.8355 | |
| ln(Adjusted crime rate) | ln(Casino Revenue) | **0.2931**** | **(0.139)** | **0.0859** | **(0.061)** |
| | ln(Clearance Rate) | -0.2895*** | (0.039) | -0.1581*** | (0.045) |
| | ln(Dow Jones Index) | -0.4099*** | (0.065) | -0.1881** | (0.085) |
| | Trend | -0.0005*** | (0.000) | -0.0009* | (0.001) |
| | Constant | 0.3846 | (0.879) | 0.8624* | (0.454) |
| | Jan | -0.0399 | (0.033) | -0.0225 | (0.016) |
| | Feb | -0.1280*** | (0.030) | -0.1288*** | (0.020) |
| | Mar | -0.1504*** | (0.032) | -0.1317*** | (0.023) |
| | Apr | -0.1253*** | (0.031) | -0.1277*** | (0.024) |
| | May | -0.1219*** | (0.031) | -0.1091*** | (0.026) |
| | Jun | -0.0959*** | (0.032) | -0.1032*** | (0.026) |
| | Jul | -0.1235*** | (0.031) | -0.1167*** | (0.026) |
| | Aug | -0.1280*** | (0.031) | -0.1249*** | (0.025) |
| | Sep | -0.1096*** | (0.031) | -0.0985*** | (0.023) |
| | Oct | -0.1077*** | (0.031) | -0.0930*** | (0.020) |
| | Nov | -0.0761** | (0.031) | -0.0748*** | (0.015) |
| | R squared | 0.6388 | | 0.4346 | |

Note: Numbers in parentheses are standard errors. Significance levels are 1% (***), 5% (**), and 10% (*).

[a] Serial correlation is detected in all three equations using the Breusch–Godfrey test. The Prais–Winsten regression is used to fix the serial correlation.

**Table 10: 3SLS Regression Results with Reported Crime Rate**

| | | 3SLS | | OLS [a] | |
|---|---|---|---|---|---|
| | Variable | Coefficient | Std. Err | Coefficient | Std. Err |
| ln(Casino Revenue) | ln(Visitors) | 1.3893*** | (0.102) | 0.6831*** | (0.153) |
| | ln(Dow Jones Index) | 0.1000*** | (0.038) | 0.2428*** | (0.057) |
| | Trend | -0.0011*** | (0.000) | -0.0005** | (0.000) |
| | Constant | 5.0473*** | (0.077) | 5.3640*** | (0.123) |
| | Jan | 0.0136 | (0.025) | 0.0518** | (0.022) |
| | Feb | -0.0400 | (0.024) | -0.0182 | (0.024) |
| | Mar | -0.1589*** | (0.029) | -0.0450 | (0.035) |
| | Apr | -0.1987*** | (0.027) | -0.1114*** | (0.032) |
| | May | -0.1435*** | (0.028) | -0.0520 | (0.033) |
| | Jun | -0.1850*** | (0.026) | -0.1256*** | (0.029) |
| | Jul | -0.1965*** | (0.027) | -0.1058*** | (0.033) |
| | Aug | -0.1912*** | (0.028) | -0.0987*** | (0.034) |
| | Sep | -0.0862*** | (0.026) | -0.0378 | (0.028) |
| | Oct | -0.1549*** | (0.028) | -0.0587* | (0.032) |
| | Nov | -0.0843*** | (0.025) | -0.0490** | (0.022) |
| | R squared | 0.7077 | | 0.8687 | |
| ln(Visitors) | ln(Casino Revenue) | 0.7930*** | (0.092) | 0.0901** | (0.036) |
| | ln(Reported Crime Rate) | -0.0922* | (0.051) | -0.0062 | (0.039) |
| | ln(Dow Jones Index) | -0.1167** | (0.051) | 0.1359*** | (0.034) |
| | Trend | 0.0006*** | (0.000) | 0.0009*** | (0.000) |
| | Constant | -3.8619*** | (0.444) | 0.0104 | (0.209) |
| | Jan | -0.0145 | (0.020) | 0.0462*** | (0.009) |
| | Feb | 0.0180 | (0.020) | 0.0295** | (0.012) |
| | Mar | 0.1075*** | (0.020) | 0.1545*** | (0.013) |
| | Apr | 0.1402*** | (0.019) | 0.1254*** | (0.013) |
| | May | 0.0992*** | (0.019) | 0.1265*** | (0.013) |
| | Jun | 0.1338*** | (0.019) | 0.0902*** | (0.014) |
| | Jul | 0.1401*** | (0.019) | 0.1296*** | (0.013) |
| | Aug | 0.1357*** | (0.019) | 0.1387*** | (0.013) |
| | Sep | 0.0576*** | (0.019) | 0.0702*** | (0.013) |
| | Oct | 0.1092*** | (0.020) | 0.1336*** | (0.011) |
| | Nov | 0.0578*** | (0.019) | 0.0511*** | (0.009) |
| | R squared | 0.7805 | | 0.8156 | |
| ln(Reported Crime Rate) | ln(Casino Revenue) | **0.3458**** | **(0.137)** | **0.0944*** | **(0.054)** |
| | ln(Clearance Rate) | -0.3286*** | (0.040) | -0.1459*** | (0.040) |
| | ln(Dow Jones Index) | -0.3737*** | (0.062) | -0.1712** | (0.079) |
| | Trend | -0.0020*** | (0.000) | -0.0022*** | (0.001) |
| | Constant | 1.2178 | (0.875) | 1.8587*** | (0.406) |
| | Jan | -0.0068 | (0.031) | 0.0123 | (0.014) |
| | Feb | -0.1053*** | (0.028) | -0.1096*** | (0.017) |
| | Mar | -0.0476 | (0.030) | -0.0283 | (0.020) |
| | Apr | -0.0418 | (0.028) | -0.0474** | (0.022) |
| | May | -0.0376 | (0.029) | -0.0225 | (0.023) |
| | Jun | -0.0362 | (0.030) | -0.0456* | (0.023) |
| | Jul | -0.0390 | (0.028) | -0.0319 | (0.023) |
| | Aug | -0.0403 | (0.029) | -0.0328 | (0.022) |
| | Sep | -0.0682** | (0.029) | -0.0525** | (0.020) |
| | Oct | -0.0239 | (0.029) | -0.0061 | (0.018) |
| | Nov | -0.0447 | (0.029) | -0.0435*** | (0.013) |
| | R squared | 0.7911 | | 0.7100 | |

Note: Numbers in parentheses are standard errors. Significance levels are 1% (***), 5% (**), and 10% (*).

[a] Serial correlation is detected in all three equations using the Breusch–Godfrey test. The Prais–Winsten regression is used to fix the serial correlation.

## APPENDIX B

### Interpolating[21] Personal Income Data

There are only 16 observations (1996 – 2011) for the personal income in Las Vegas area (Clark County) because the County level income data are only available on yearly basis. Annual per capita personal income data for Las Vegas can be interpolated using the quarterly Nevada personal income data that are collected from Bureau of Economic Analysis (http://www.bea.gov/) assuming the income data of Las Vegas and Nevada follow the identical distribution.

Let $PI^{NV}_{year,quarter}$ is the Nevada personal income in quarter in year, for example $PI^{NV}_{2000,q1}$ is the income in the first quarter in year 2000. Also let $PI^{LV}_{year,quarter}$ is the Las Vegas personal income in the quarter in year. Interpolation is given by

$$PI^{LV}_{year,quarter} = \frac{PI^{LV}_{year} \cdot PI^{NV}_{year,quarter}}{\sum_{quarter=Spring}^{Winter} PI^{NV}_{year,quarter}},$$

where $PI^{LV}_{year}$ is the annual Las Vegas personal income data available from 1996-2011.

[21] Interpolation is a method of constructing new data points within the range of a discrete set of known data points.